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ENVIRONMENTAL STATUS OF THE LAKE MICHIGAN REGION

**VOLUME 9. SOILS OF THE LAKE MICHIGAN DRAINAGE
BASIN--AN OVERVIEW**

**FOREST STEARNS, FRANCIS D. HOLE,
AND JEFFREY KLOPATEK**

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ENVIRONMENTAL STATUS OF
THE LAKE MICHIGAN REGION

Volume 9. Soils of the Lake Michigan Drainage
Basin--An Overview

by

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and Jeffrey Klopatek*

Consultants to
Environmental Statement Project

June 1974

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PREFACE

Assessments of the environmental impacts of individual nuclear power plants sited on the shores of Lake Michigan have led to increased recognition of the need for regional considerations of the environmental impacts of various human activities, and a compendium of information on the environmental status of the region for use in assessing such impacts. In response to these needs, a report series describing the status of Lake Michigan and its watershed is in preparation. The series is entitled "Environmental Status of the Lake Michigan Region"; this report is part of that series.

The report series provides a reasonably comprehensive descriptive review and analysis of natural features and characteristics, as well as past, present, and proposed natural processes and human activities, that influence the environmental conditions of Lake Michigan, its watershed, and certain adjacent metropolitan areas. This series will constitute a regional reference document useful both to scientific investigators and to other persons involved in environmental protection, resource planning, and management. In these regards, the "Environmental Status of the Lake Michigan Region" will serve in part as an adjunct to reports of broader scope, such as the Great Lakes Basin Commission's Framework Study.

Other Volumes Published to Date in This Series

Vol. 7. Earthquake History and Measurement with Application to the Lake Michigan Drainage Basin. Richard B. Keener. NTIS-\$4.00. 19 pp.

Vol. 15. Mammals of the Lake Michigan Drainage Basin. Charles A. Long. NTIS-\$5.75. 109 pp.

REPORT

REPORT

REPORT

Assessment of the environmental impact of individual projects is a task which has not been adequately recognized in the past. For regional consideration of the environmental impact of projects, a comprehensive and systematic approach is required. It is necessary to have a systematic approach to the assessment of the environmental impact of projects. The report is divided into two parts: the first part is a general approach to the assessment of the environmental impact of projects, and the second part is a detailed approach to the assessment of the environmental impact of projects.

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Other volumes published to date in this series

Vol. 1. Environmental History and Development. A. H. Johnston. 1970. 112 pp. \$1.50.

Vol. 2. Methods of the Environmental Impact Assessment. 1971. 112 pp. \$1.50.

ENVIRONMENTAL STATUS OF THE LAKE MICHIGAN REGION
VOL. 9. SOILS OF THE LAKE MICHIGAN DRAINAGE BASIN--AN OVERVIEW

by

Forest Stearns, Francis D. Hole, and Jeffery Klopatek

Abstract

This report summarizes existing information on soils of the Lake Michigan Drainage Basin. Soil functions, morphology, classification, and land-capability scheme are described in the text. Distribution of major soil groups is compiled for the basin area, wherein, the Podzols soil group is most abundant. The Brown Podzols account for about 46 percent of the basin area, and another 30 percent of the basin land is composed of Gray-Brown Podzols.

Under favorable climatic conditions, forest land has been converted to agricultural land. However, forests appear to be prevalent and comprise the major land use of the basin soils. Agriculture ranks second. Increasing urbanization also has made its impact on soil use within the basin. In these urbanized areas soils are now covered largely by asphalt and concrete constructions.

INTRODUCTION

Man is intimately dependent on the soil because of his need for food the soils produce. Therefore, one would expect detailed consideration of the soil before changes are made in land use. Too often this has not been the case. Urbanization and highway construction have destroyed or paved over many acres of prime agricultural soils; each year more than one million acres of agricultural land in the United States are converted to urban use (Conservation Needs Inventory Committee, 1965). Wetlands, important as watershed recharge areas and nutrient sinks, have been drained and filled; four billion cubic yards of sediment are deposited in the lakes, rivers, streams, estuaries, and reservoirs each year (Powell *et al.*, 1970), primarily because of construction practices and lack of ground cover. Soil is a renewable resource only when it is given enough time for development; advancing urbanization and greater mobility of the population continue to multiply the pressure on the most valuable soils.

Increasing pressure for land utilization has resulted in several detailed reports on soils in relationship to land use (e.g., SEWRPC, 1966). It is, however, a monumental task to produce a detailed report on an area the size of Lake Michigan's drainage basin. This report, consequently, will attempt to

give an overview of the types of soils found in this area with an insight into their classification and capabilities. A supplemental report is in preparation and will be an extended and comprehensive treatment of the soils of the Lake Michigan Drainage Basin.

Soils can be examined either pedologically, as weathered, biochemical products of the environment, or edaphically, as habitats for plant growth. Pedology considers soil purely as a natural body with minor emphasis on immediate practical use. Certain phases, such as the origin of the soil, its classification, and description, are included in the field of study designated as pedology. The findings of the pedologist may be as useful to highway and construction engineers as to the farmer.

Edaphology considers the various properties of soils as they relate to plant production. The edaphologist has the production of food and fiber as the ultimate goal, but he tries to determine reasons for variation in the productivity of soils and to find means of conserving and improving productivity (Buckman and Brady, 1960).

Both approaches will be employed to varying degrees throughout this report, depending on the information available. For more detailed information or clarification, appropriate references are listed.

All soils in the basin are relatively young (less than 14,000 years old), and their parent materials are in some fashion related to glacial activity and deposition. The parent materials include unsorted till, loess, outwash sands in level dry plains, and lake clays, silts, and fine sands. Often the transition from one mixture to another is abrupt, and evident changes in vegetation suggest differences in the underlying soil. The dynamic organic fraction is largely the product of recent and current vegetation. The distinct soils of the northern and southern parts of the basin are separated by a belt or zone of transitional soils, which corresponds to the area of transition between northern and southern climates and vegetation.

There are about five hundred recognized soil series within the basin and perhaps at least as many more present but unnamed. These soils are commonly two to five feet deep over the parent material. The origin, classification, capacities, and limitations of these soils are discussed in the sections to follow.

SOIL FUNCTIONS

The soil is involved in the cycling of water and other materials and participates actively in the transformation of solar energy through absorbing, transmitting, retaining (for short periods), and dissipating heat received from the sun.

Precipitation falling on the land surface is absorbed by the soil or runs off the surface. Soil erosion may occur in the runoff process, even under natural vegetation if rainfall is intense, but it is aggravated by removal of vegetative cover--either in the course of crop production or, with

more serious effects, because of construction or other human activity. Increased areas of impermeable surfaces resulting from road construction and urbanization may multiply runoff and erosion problems if positive landscape and soil management practices are not instituted.

Water entering the soil is taken up by vegetation or percolates downward to the water table from which it may be lost by seepage, pumping, or uptake by deeper-rooted plants. Organic substances in the percolating water may be broken down by soil microorganisms; nutrients may be absorbed by, or adsorbed on, the textural particles. Mineral materials may also enter the water table as pollutants; for example, high nitrate wastes may produce toxic concentrations of nitrates in the ground or runoff waters. The behavior of water in the soil depends on the textural mixture, the organic matter, and the soil morphology, i.e., the presence or absence of impervious or slowly pervious layers.

Similarly, soil is closely linked to the cycling of nutrients; these may reach the soil as litter, dead roots, and various organic wastes or even as atmospheric fallout with dust or in solution in precipitation. The textural mixture and chemical nature of the soil influence the degree to which minerals are adsorbed and retained or are leached out of the soil layer.

Concentrations of toxic elements such as Hg, Cd, Sr⁹⁰, Cs¹³⁷, or other materials such as sulfur compounds may at times exceed the adsorptive capacity of the soil, but soil has a remarkable capacity to store these materials and to slow or prevent their movement into water bodies. Organisms in the soil reduce biodegradable compounds to innocuous, or even nutritional, components and convert the accumulations of organic debris to carbon dioxide, water, and nutrients.

SOIL MORPHOLOGY AND GENESIS IN THE DRAINAGE BASIN

The origin of the soils of the Lake Michigan drainage basin is closely related to glacial history. Successive advances of the Pleistocene ice sheet brought in new parent material and mixed those materials already present. Present soils began to develop with the final retreat and disappearance of the Wisconsin ice. The deposits range from a few feet to several hundred feet thick. Most of these materials were derived locally from underlying bedrock, or from material laid down by previous glaciations, or were formed by weathering in pre- or interglacial times (NC Regional Tech. Comm., 1960).

As a result of the glaciation, the underlying bedrock functions directly as a primary parent material only in scattered outcroppings in this region. The primary parent material is the unconsolidated mineral mass from which the upper layers (A and B horizons) of soil have been developed. If the parent material is immediately below the A and B horizons, that material is referred to as the C horizon.

A complete definition of the parent material should include at least the chemical and mineralogical composition, texture, and fabric or structure, as these properties determine in part the characteristics of the soils eventually

developed. In addition to material of glacial or bedrock origin, parent material can also be fluvial, aeolian, or lacustrine; all are represented in the drainage basin. This material provides the mineral base in soil formation, but loses its identity during the process. Topography, climate, living organisms, and time all play major roles in production of a mature soil.

As earlier noted, soil parent materials in the basin include unsorted till, recessional or terminal moraines, silt, loess, and lacustrine deposits of a few millimeters to several centimeters thick. Fine-textured materials laid down in ancient lakes and outwash sands deposited in level or undulating sand plains may reach considerable thickness (over 25 m) in some locales. Large areas of peat and muck were derived from and now form the substrate for wetland vegetation, and in a few places thin soils have developed over exposed dolomites, sandstones, or granites.

There are readily recognized differences between soils and vegetation that develop on sand (coarse-textured) and those that develop on silty or clay (fine-textured) parent materials. Likewise, soils develop differently in well-drained locations than in saturated locations. The topographic position and the presence of either impermeable layers of clay or highly permeable strata of sand or gravel also influence available moisture and soil development. Soils derived from the granitic rocks of the Canadian Shield or from ancient quartz sandstones are less productive than those formed from limestones or shales, because of the latter's greater cation exchange capacity. Abundance of organic matter in the surface soils, as in virgin forests and prairies, may lessen these differences somewhat.

Basin topography ranges from level to undulating; steep slopes are associated primarily with the terminal moraine systems and with other glacial features such as drumlins and eskers. Steep slopes occur along the western side of the Niagara cuesta in Wisconsin and on the water-cut bluffs along the western shore of the lake.

A few stream valleys leading into Lake Michigan have cut deep ravines in the bluffs. Steep slopes tend to influence soil thickness, resulting in thinner soils, and moisture availability varies accordingly. However, the chief effect of topography on soils in the basin is probably the accumulation of water in depressions, producing bogs, lakes, and extensive wetlands.

The basin climate is generally moist, with conditions favorable for plant growth. Precipitation is sufficient to permit leaching under the cool climates in the northern part of the basin; iron and aluminum are removed from the surface horizons and deposited in the subsurface hardpan or illuvial layers. The soils are subject to freezing and thawing, particularly in the southern portion of the basin. This helps to break up the compaction produced in the clays and fine loams by cultivation or construction activity. In the northern portion of the basin, snow cover usually limits soil freezing, expediting infiltration of water from the winter snow pack. Past climate has had an influence, especially in the south, where dark prairie soils developed under grassland during the warm and dry periods.

Organisms dominate soil development, and throughout most of the basin the climate, textural mixtures, and soil fertility favor vigorous plant growth, diverse populations of soil invertebrates and small mammals, and abundant

development of soil microorganisms.

Although the parent materials of the basin are all relatively young, there has been ample time for notable soil development, except for very dry or excessively wet sites. (Soil development is a continuous process, and as vegetation changes, the direction of soil genesis may change also.) Old field areas and surfaces stripped bare show little if any profile development, whereas cultivated fields frequently show loss of the upper soil layers.

A typical well-developed soil shows several distinct horizons or layers. These usually include highly organic surface layers with an abundant variety of life. In the cool, moist climates of the basin, especially in the north, considerable leaching below the surface layer results in removal of clay minerals, iron, and aluminum compounds, leaving a light-colored leached layer (A-2 horizon or albic horizon). The leached materials move downward and are deposited in a brownish or yellowish subsoil layer (or B horizon), where the organic matter and iron and aluminum oxides and clays bind the soil particles forming a hardpan. This layer grades into the parent material.

Where drainage is poor, a mottled blue-gray gley layer is formed. Poorly drained soils show less profile development than better aerated ones. Organic soils form in saturated sites with raised water tables, where cool temperatures and acid and anaerobic conditions prevent decomposition. Soils developing under grass show some leaching and accumulation, but are conspicuously dark throughout the upper horizons as a result of accumulation of organic matter from grass roots.

CLASSIFICATION OF THE DRAINAGE BASIN SOILS

Many systems of soil classification have evolved, including those based on textural composition and those based on profile genesis or appearance.

Lake Michigan basin soils can be classified simplistically by texture or textural mixtures as:

Sandy soils	Well drained, droughty, quick to warm and cool, and relatively low in nutrients.
Loamy soils	Usually highly productive, well drained but with good water-holding capacity.
Clay and silty-clay soils	Usually productive, with high water-holding capacity, but droughty, often poorly drained with a tendency to water-logging.
Organic	Peats and mucks usually acid, wet, cool, lacking aeration and essential nutrients for plant growth.

This elementary classification is useful to the agriculturalist and engineer as well as to the ecologist. However, it does not take into account the many intergrading textures, vertical layering, drainage, and nutrient

combinations nor the effects of profile development under the influence of climate, vegetation, associated soil animals, and microorganisms.

A comprehensive soil-classification system was developed by Russian soil scientists and was extended to the soils of the United States by Baldwin, Kellog, and Thorp (USDA 1938 Yearbook of Agriculture entitled, "Soils and Men"). This classification, based largely on soil development and morphology, was utilized in most soils studies and maps published before 1960 as well as in many published later.

A new United States comprehensive soil-classification system was first published in 1960 and was revised and republished in 1964 and 1967. This system is based on the physical characteristics and appearance of soils and is the standard classification today. A key to this classification is outlined in Table 1. The revised 1960 classification is accepted internationally and will gradually come into general use. However, most maps and soil surveys now available are based on the 1938 classification. Therefore, the description of regional soils below uses the 1938 classification.

Broad categories of soils have been differentiated on a regional basis into six groups (NC Regional Tech. Comm., 1960) as follows:

1. Dark-colored soils developed under prairie.
2. Light-colored soils developed under forest.
3. Dark-colored soils with restricted drainage.
4. Soils with dense clayey subsoil.
5. Immature and shallow soils on steeper slopes.
6. Alluvial soils of stream bottomlands.

Groups 4-6 are missing or insignificant in the Lake Michigan basin; Groups 1-3 each cover major areas. Eight of the 17 associations of Great Soil Groups mapped for the North Central Region occur in the basin (Fig. 1). Descriptions of these have been modified from NC Regional Tech. Comm. (1960) and follow.

BRUNIZEMS AND HUMIC GLEY

These soils are developed under grass over a range from well to poorly drained sites and on parent materials varying from sand to clay. When formed on silty soils, they are very productive. The dark, slightly leached horizons are high in organic matter and are not easily differentiated. Most Brunizems are of medium texture, slightly acid near the surface, and become neutral to slightly alkaline in the parent material. When poorly drained, a mottled gray layer is present. These soils occur in only three small areas (occupying about 1% of the basin area) in the southern part of the basin, but are widespread in Illinois and Indiana (outside the basin).

Table 1. Generalized Soil Key to the Soils of the World (USDA 7th approximation classification) Indicating by Shading the Six Soil Orders Represented in the Lake Michigan Basin.
Adapted from F. D. Hole, 1974. *Wisconsin Soils*. Bull. 87.
Wis. Geol. and Natural History Survey, Univ. Wis. Madison.

		ORDERS		SUB ORDERS			
Soils of the World	Mineral soils (usually <25% organic matter)	Soils with few features; little weathered	A horizon rests on C	Soils not dominated by swelling clay	ENTISOLS (Regosols Lithosols)	Aquepts Fluvents Arenets Psamment Orthents	
			A horizon is over weak B	Soils dominated by swelling clay	VERTISOLS (Grumusols; self-plowing soils)	Uderts Usterts Xererts Torerts	
		Soils with distinct B horizons; moderately weathered	B is enriched in clay	Soils usually moist	INCEPTISOLS (Humic Gleys; Acid Brown Forest soils)	Plaggepts Aquepts Andepts Ochrepts Tropets Umbrpts	
				Soils usually dry	ARIDISOLS (Desert soils)	Argids Orthids	
		Soils highly weathered; infertile	B is enriched in organic matter and iron	Soils usually moist	Thick, soft, black A1; fertile	MOLLISOLS (Grassland soils)	Albolls Udolls Borolls Aquolls Ustolls Xerolls Rendolls
					Thin A1 over A2	Fertile C	ALFISOLS (Gray-Brown Podzolics)
				Less Fertile C	ULTISOLS (Red-Yellow Podzolics)	Aqualts Humults Udults Ustults Xerults	
			SPODOSOLS (Pozols)	Orthods Ferrodss Aquods Humods			
			OXISOLS (Latosols)	Aquoxs Humoxs Orthoxs Ustoxs Torrox			
		Organic soils (usually >25% organic matter)			HISTOSOLS (Peats, Mucks Bog soils)	Folist Fibrists Hemists Saprist	

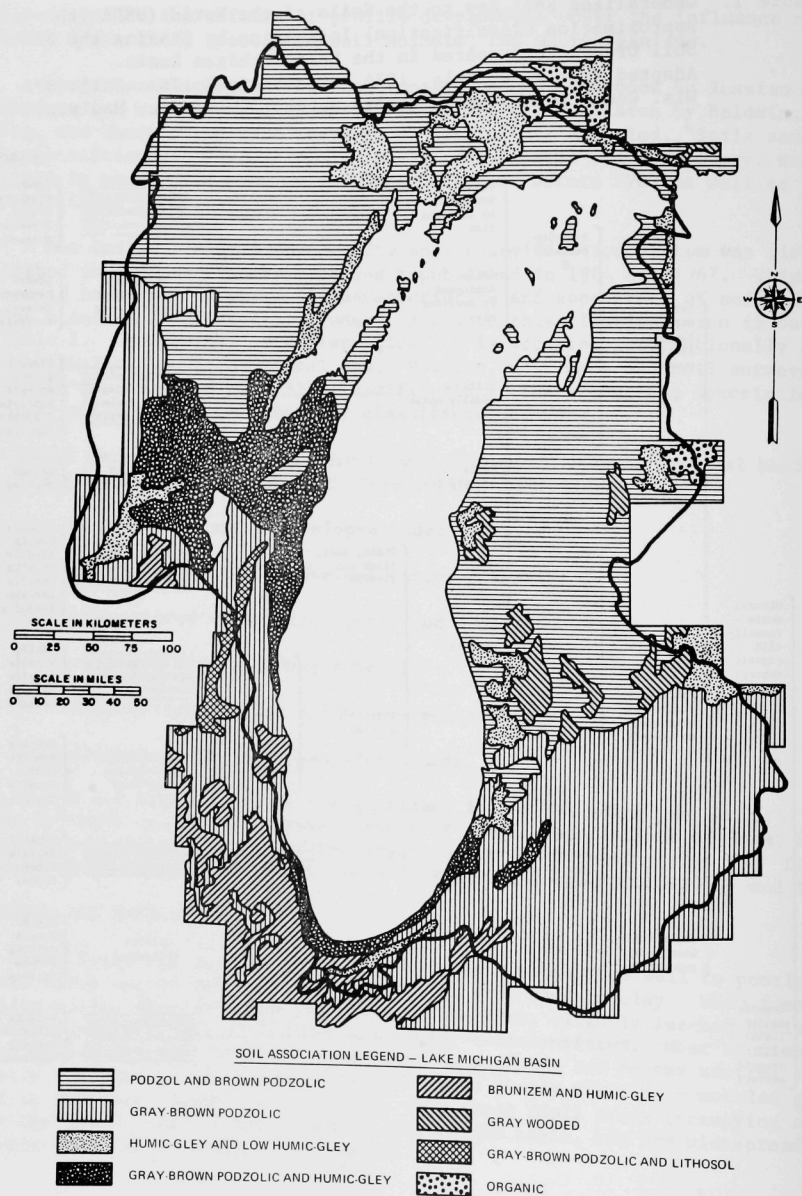


Fig. 1. Major Soils of the Lake Michigan Basin.

GRAY-BROWN PODZOLIC SOILS WITH HUMIC GLEYS AND WITH LITHOSOLS

These are generally productive soils developed under deciduous forest cover (oak-hickory and beech-maple, i.e., mesic and dry southern forest) on a range of parent materials from coarse sands to fine-textured sediments with good to moderate drainage. In general, clay-forming materials were available, and silicate clays accumulate in the B horizon. The profiles show a thin organic horizon, a brownish-gray organic layer underlain by a lighter layer from which clays, iron, and organics have been leached. Below, a higher clay content is found in the B horizon which is yellowish-brown in color and somewhat blocky in structure. In poorly drained areas, Gley soils are usually present as they were with the Brunizem association. Likewise, on the drier and well-drained sites and on steep slopes, or where rock crops out near the surface, Lithosols are found. Gray-Brown Podzolic soils occupy large areas in the southeastern and western parts of the basin, covering approximately 30% of the basin area. Gray-Brown Podzolic and Humic Gley soils occur in the west central portion south of Green Bay and in a narrow band at the southern end of Lake Michigan, accounting for about 11% of the basin area. A band of Gray-Brown Podzolic with Lithosols is present in the west central area and covers less than 0.5% of the basin.

GRAY WOODED SOILS

These soils are limited to a few areas in Michigan's central Lower Peninsula (about 2% of the basin), where mixed deciduous-conifer forest occurs on areas of calcareous till of medium to fine texture (loams to silty clays). A surface layer containing mor humus lies immediately over a light-colored leached horizon which, in turn, is underlain by a fine-textured browner B horizon, often with a limy layer. The entire profile is lighter than that of the Gray-Brown soils and is usually less acid and high in bases.

PODZOLS AND BROWN PODZOLIC SOILS

These soils differ chiefly in the degree of leaching of the A₂ horizon, in part a result of the dominant vegetation. The Podzols and Brown Podzolic soils developed in the cooler northern portion of the basin under coniferous, broad-leaved, or mixed forest, over a wide range of topography; parent materials vary from loamy till to outwash sand. In the basin they cover most of the northwestern and northeastern areas, occupying approximately 46% of the basin area. The parent material is generally noncalcareous, but in the northern Lower Peninsula of Michigan and eastern Wisconsin, Podzols have also developed from slightly to strongly calcareous drift of similar textures (NC Regional Tech. Comm., 1960).

The Podzol profile shows a thick organic layer underlain by a thin layer of mineral soil infiltrated with organic matter. This in turn is underlain by a light-colored leached layer 4-10 inches thick. An illuvial or enriched B horizon, reddish-brown or brown, lies below the leached layer and is often cemented into a hardpan. Horizons in the Brown Podzolic soils are less well developed, the leached layer is missing, and the B horizon less conspicuous. A "double" profile, in which several leached and accumulated horizons are developed, appears in some soils.

HUMIC GLEY SOILS

Poorly drained sites result in the formation of gley profiles which may be associated with Brunizems or Gray-Brown Podzolic soils. Humic soils are found throughout the basin, with the largest areas in the north, but they occupy only 8% of the basin area.

These soils form in depressions or on relatively level topography and may support wet prairie, sedge meadows, or lowland (wet) hardwood forest. In suitable climatic conditions, these soils are sometimes drained and are then very productive.

A thick black A horizon is developed by the accumulation of organic matter; this is underlain by an olive-gray mottled upper C layer of parent material. Organic material may constitute as much as 10 percent of the upper horizon; it decreases with depth.

BOG (ORGANIC) SOILS

Peat and muck soils occur in small pockets that are widespread throughout the basin. They range from 30 to 100 percent organic matter in the surface layers and vary in degree of decomposition. Material forming muck soils is well decomposed; that in peats is often fibrous with well-preserved plant material. The pH of organic soils varies. In the northern portion of the basin, the soils are often highly acid. Peats and mucks form in depressions that are subject to frequent late and early frost, usually under saturated conditions.

MAJOR SOIL TYPES OF STATES IN THE DRAINAGE BASIN

The ensuing discussion describes the geographical distribution of major soil types in the political units of the basin.

INDIANA

That portion of Indiana included in the Lake Michigan drainage basin is designated as the Northern Moraine and Lake Region. Subunits of this region are the Calumet Lacustrine Plain, Valparaiso Morainal Area, Kankakee Outwash and Lacustrine Plain, and the Steuben Morainal Lake Area (Schneider, 1966). Elevation generally ranges from 600 to 800 feet, some knobs reaching a height of 950 feet. The varied topographic features are the result of glaciation. Excellent examples of shoreline dunes and sandy beaches are common along the Lake Michigan shoreline. Ice-block depressions, knobs, kames and lake plains are common throughout the area. Postglaciation alteration, consisting primarily of broad aeolian deposits of sand, filled in glacial depressions creating numerous peat bogs, and many lakes, set northern Indiana apart from the rest of the state.

Parent materials of Indiana soils were deposited by glacial action and include unconsolidated ice and waterborne materials.

Great Soil Groups found in this region of Indiana are Brunizem, Gray-Brown Podzolic, Humic-Gley, Low-Humic Gley, and Bog soils (see map in NC Regional Tech. Comm. Publ. No. 76, 1960). Orders of the United States Comprehensive System include Alfisols, Entisols, Histosols, Inceptisols, and Molisols. Surface-soil textures are chiefly fine sandy loams, loams, silt loams, and heavy silt loams. Subsoil permeability, an important consideration in agriculture, varies greatly.

ILLINOIS

The Lake Michigan drainage basin encompasses only Cook, Lake, and an edge of Will Counties in Illinois, although McHenry, Kane, DuPage, and Will Counties are immediately adjacent. This entire area was covered by Wisconsin glaciation, and thick deposits of glacial drift are responsible for most of the relief. The region is characterized by irregularly shaped hills, morainal ridges, eskers, kames, and kettle holes in the northern part, with level plains and gently rolling lands in the south. Elevation varies from 500 to over 1100 feet above sea level, most of the region lying between 700 and 800 feet.

Parent material consists chiefly of glacial outwash and till, with the only appreciable deposit of loess in western Kane County. Outwash materials consist of sands, silts, and clays. Glacial tills include a wide range of textural combinations in northeastern Illinois consisting of sandy loam, loam, silty clay, silty clay loam, and loamy gravel. Small areas of lacustrine sediments are present (Wascher *et al.*, 1960).

Major soil orders occurring in the northeast section of Illinois are Mollisols, Alfisols, and Histosols, with some Entisols along streams and in very sandy areas. Great Soil Groups, according to the 1938 U. S. Department of Agriculture classification, would include Brunizems, Gray-Brown Podzols, and Humic-Gleys (Univ. of Ill., 1967).

WISCONSIN

Glaciation played a major part in the distribution of parent material for the soils in the Wisconsin portion of the Lake Michigan drainage basin. Moraines, lacustrine deposits, and glacial outwash dominate the area. Underlying bedrock is primarily dolomites of Silurian, Ordovician, and Cambrian age in the eastern and southeastern sections (responsible for the calcareous till) and Pre-Cambrian gabbro, basalt, and granite in the northeastern section.

Elevations range from 500 feet above sea level for the lowlands in the southeastern section to slightly more than 1950 feet in the northern section (Martin, 1932). Drumlins, eskers, kames, kettle holes, thousands of lakes, and numerous marshes and bogs are scattered throughout the region. Topography is generally undulating or rolling, with some areas of level outwash plains.

Glacial action resulted in parent material of diverse textures, including calcareous loams, clay loams and clayey till, silty clay loam, silty clay, clay till sands, and lacustrine deposits. Locally thin to moderately thick surface deposits of loess are also found, and a few major areas of aeolian sand deposits exist. Occurring in this region are Alfisols, Entisols, Histosols, Inceptisols, Mollisols, and Spodosols. Corresponding Great Soil Groups include Gray-Brown Podzolics, Brunizems, Lithosols, Regosols, Humic-Gleys, Podzols, Bog soils, Gray-Wooded soils, Acid-Brown Forest soils, and Alluvial soils (Hole, 1974).

MICHIGAN

Michigan owes the basis of its soils to the effects of glaciation. Morainic, fluvial, and lacustrine deposits predominate in the region. Underlying bedrock includes Cambrian and Ordovician dolomite, limestone, shale, sandstone, and granite. Elevation varies from 400 to 1700 feet above sea level in the southern peninsula and 600 to 2000 feet in the northern peninsula. Physiography is typical for a glaciated area; moraines, outwash plains, kames, kettle holes, and eskers are common. Topography, although generally undulating and rolling, is characterized by a variety of linear ridges and cliffs, plateau ridges, rock knobs, U-shaped valleys, and broad, flat plains.

Major parent materials of the soils are clay, silty clay, clay loam, loam, sandy loam, loamy sand, and sand. Comprehensive Soil Classification System soil orders present are Alfisols, Entisols, Histosols, Inceptisols, Mollisols, and Spodosols (Schneider *et al.*, 1967). Corresponding Great Soil Groups are Brunizems, Gray-Brown Podzolics, Humic-Gleys, Bog soils, and Podzols.

CAPABILITY CLASSES AND LAND USES RELATED TO SOILS

Soils in the Lake Michigan Basin support a wide range of land uses from the one extreme of "wild" soils on which no management has ever been practiced, to soils that have been completely paved over, with the resultant loss of the soil biota and the destruction of the soil. This section summarizes briefly the capability-class concept and various land uses related to soil characteristics.

In the belief that all land should be utilized in accordance with its limitations and capabilities, a system was established by the United States Soil Conservation Service to divide land into eight land-capability classes. These units are practical groupings based on the limitations of the soils, the risk of damage when they are used, and their response to treatment. The following is a description of the system currently in use, taken directly from the Southeastern Wisconsin Regional Planning Commission (1966).

In this system all soils are grouped at three levels: the capability class, subclass, and capability unit. The eight capability classes in the broadest grouping are designated by Roman numerals I-VIII. In Class I are the soils that have few limitations, the widest range of use, and the least risk of damage when they are used. The soils in the other classes have progressively greater natural limitations. In Class VIII are soils and land forms so rough, shallow, or otherwise limited that they do not produce economically worthwhile yields of crops, forage, or wood products.

The subclasses indicate major kinds of limitations within the classes. Within most classes there are up to four subclasses. The subclass is indicated by the addition of a lower-case letter, e, w, s, or c, to the class numeral, as for example IIe. The letter e indicates that the main limitation on the use of the soil for cultivated crops is a risk of erosion unless close-growing plant cover is maintained; w

indicates that water in or on the soil will interfere with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); s indicates that use of the soil for cultivated crops is limited mainly because it is shallow, droughty, or stony; and c indicates that the use of the soil for cultivated crops is mainly limited because of climate that is too cold or too dry.

There are no subclasses in Class I because the soils in this class have few or no limitations. Class V can contain only subclasses w and s because the soils in this class have little or no risk of erosion but have other limitations that restrict their use mainly to pasture, woodland, or wildlife.

Each subclass is further divided into capability units. These consist of groups of soils that are similar and therefore suited to the same kinds of crop and pasture plants, require similar management, and have similar productivity and other responses to management. Thus, the capability unit is a convenient grouping of soils for management purposes. Capability units are identified by the addition of an Arabic numeric code to the class and subclass code, as for example IIe-1 or IIIe-2.

Soils are classified in capability classes, subclasses, and units in accordance with the degree and kind of their permanent limitations, but without consideration of major and generally expensive land-form modification that would change the slope, depth, or other characteristics of the soil, and without consideration of possible but unlikely major reclamation projects.

Knowledge of the land-capability class is useful in determining the impact of land-use changes. At the minimum, land in Classes I and II should be retained for agricultural uses. The land-capability designation provides a useful shorthand for classification.

LAND USES DEPENDING UPON SOIL CHARACTERISTICS

Agriculture and forestry are by far the most extensive and important land uses within the Lake Michigan Basin. Acceptability for these uses varies with soil physical conditions, fertility status, and available moisture. In addition, agricultural uses are dependent upon a favorable climate with a growing season of adequate length, the characteristics of the crops to be grown, and the nature of the agricultural enterprise. Intensive use of the land for forestry is also dependent upon climate and soil characteristics. Orchards represent a special agricultural use, the success of which is conditioned not only by soil characteristics but also by particular climatic features associated with Lake Michigan. The tempering of the spring with gradual warming reduces the chance of early frost and destruction of flowers, and the delayed autumn permits continued growth.

Numerous other uses are related to soil factors. Park and recreational use is favored by soils with good drainage, resistance to compaction, and fertility sufficient to support a strong vegetative cover. Wildlife production is favored by wet or moist sites with fertile soil. Pond construction is most successful in medium-textured soils on nearly level areas. Low fertility is often an advantage in pond building unless the pond is to be used to "farm" fish.

Construction is simplified on well-drained soils of coarse textures (sands, sandy loams) and is complicated in fine-grained soils, especially where deep organic soils have developed. In highway construction, peat is often removed completely and replaced by sand; home construction in tight soil (clay) requires careful attention to foundation drainage. Soil strength depends on both texture and moisture content.

Disposal of waste water and recharge of underground aquifers are functions closely related to the nature of soil and parent material. Permeability and infiltration rates and nutrient absorption/adsorption capacity regulate the suitability of a soil to handle nutrient-rich waste waters (Schneider and Erickson, 1972). The presence of vegetation with active humus layers contributes to the rapid breakdown of organic matter sprayed on the soil, and affects the degree to which water is removed and the amount of nutrient picked up from the percolating water.

Soils with clay layers or hardpans, and soils composed entirely of fine materials, do not permit infiltration of liquid or ready recharge of groundwater. In contrast, soils composed of coarse material such as sands and gravels, although usually well drained and highly permeable, have little ability to absorb nutrients.

Poorly drained soils are likewise poorly aerated, so that decomposition of organic material is retarded and a tight mottled layer is often present.

A vigorous stand of vegetation will transpire large quantities of water during the growing season, but evaporation is reduced during the cooler seasons, thus limiting year-round use of some soils for liquid-waste disposal.

Probably the most favorable combination for waste disposal from individual residences would involve an efficient aerated system from which the effluent would be carried into a shallow distribution system covered with medium-textured soil and vegetation to absorb the nutrients or hold them in the base exchange. Harvest of the lush plant growth would maintain a nutrient flux.

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